



DØ Luminosity Review

(Preliminary & Main Findings)

Introduction

Basic Methods

Overview of luminosity system

Observations & Recommendations

H. Weerts

*Michigan State University
for luminosity review committee*

This is not the final report
and NOT all the details

Quite a journey.....



Charge from the spokes:

The committee should conduct a vertical review of DØ's plans for luminosity determination for physics analysis. The review should cover all components of the system: hardware, electronics, data acquisition, storage and processing of luminosity information, and tools for physicist access. A draft report will be available February 14th and a final report March 1st.

The review should attempt to answer the following questions:

- Does the system, as conceived, meet DØ's needs for physics analysis? Does it support all the kinds of analysis we will carry out?
- Is the system robust (does it allow us to recover from loss of luminosity data, from loss of tapes, streams etc.)
- Are the present resources adequate to deliver the system in a timely manner? Are the appropriate priorities set?

Committee:

Elizabeth Gallas, Marumi Kado, Greg Landsberg, Adam Lyon,
Andrei Nomerotski, Paul Slattery, Mike Tuts & Harry
Weerts



Meetings & Presentations

H.Weerts

Dec 6, 2002	"Introduction to luminosity"	by H.Schellman
Jan 23, 2003 (online)	"Run II Hardware & Electronics"	B.Casey
	"Overview of the online lum system"	M. Begel
	"Status of simulation & analysis"	M.Begel et al
Jan 31, 2003	Committee only meeting	
Feb 7, 2003 (offline)	"Offline book keeping"	M. Verzocchi
	"Lum off line access & future database"	H.Schellman
	"Luminosity and Analysis Tools"	A.Lyon

All talks & other information are available from review WEB page:

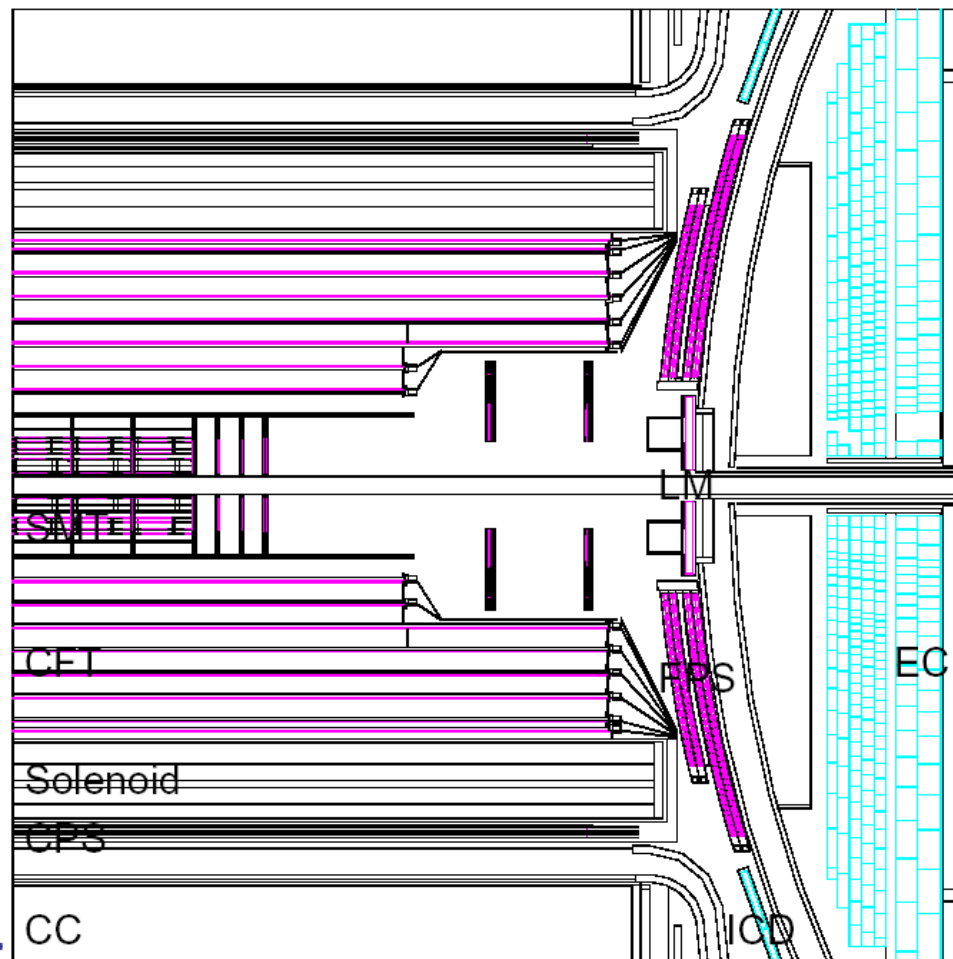
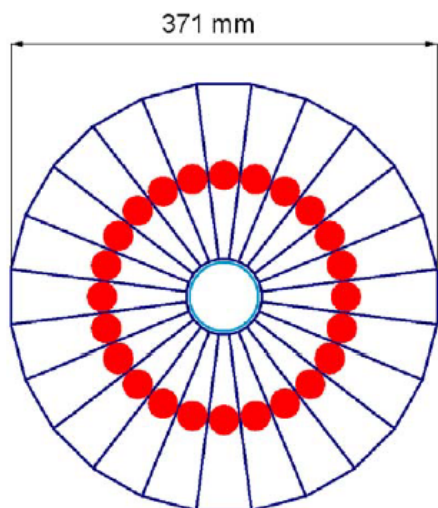
http://d0server1.fnal.gov/projects/meetings/lumreview/lum_review.htm

or luminosity ID WEB page:

http://www-d0.fnal.gov/phys_id/luminosity/

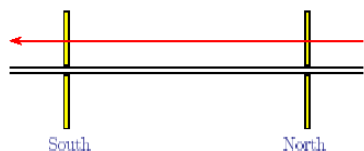
Luminosity Monitor

- Plastic scintillators with photomultipliers.
- 24 wedges mounted on each calorimeter end-cap at $z \approx \pm 140\text{cm}$.

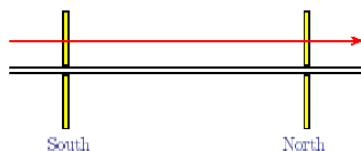


- Coverage is $2.7 < |\eta| < 4.4$.
- Located in ≈ 1 Tesla magnetic field.
- Time-of-flight resolution ≈ 200 ps.

Proton Halo



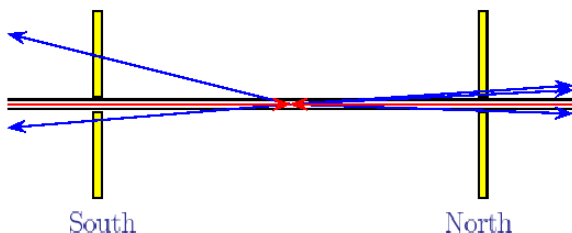
Anti-Proton Halo



Coincidences (N^+S) are stored in scalars per accelerator tick and Level trigger bit

Counting Zeros

Luminosity (Collisions)



The average number of interactions per beam crossing, μ , is proportional to the luminosity and follows a Poisson distribution. The probability of n interactions in a given crossing is

$$P(n) = \frac{\mu^n}{n!} e^{-\mu}.$$

The probability of at least one interaction (detector signal) is

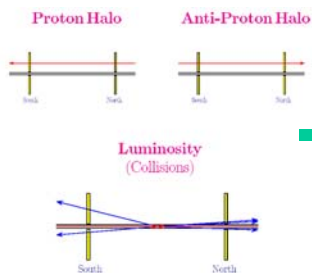
$$P(n > 0) = 1 - e^{-\mu}.$$

Since $\mu = \mathcal{L}\sigma_{\text{eff}}/\text{crossing rate}$,

$$\mathcal{L} = -\frac{\text{crossing rate}}{\sigma_{\text{eff}}} \ln(1 - P(n > 0))$$

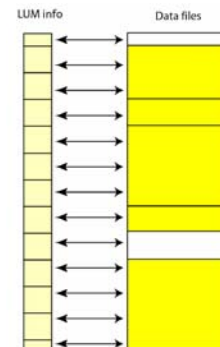
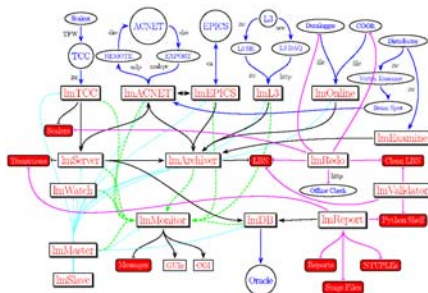
Currently no other information from LM counters is read out or stored.
Hardware not available.

$\sigma_{\text{eff}} = 43\text{mb}$ (estimate)
Crossing rate = 7.58MHz



TFW
TCC

Luminosity Data Acquisition



- Coincidences are stored in TFW scalars
- Readout via TCC to LDAQ on online

- Read out the per bunch scalars
- Calculate the instantaneous lum
- Report the instantaneous lum back to ACNET
- Store the lum info on the online system
- Monitoring of per bunch intensities and halo
- Consistency checks for each LBN (missing rates in/out of L1, L2 & L3 consistent?)
- Very stable & runs all the time
- Weekly & Monthly reports

Small upgrades

- Condensed version of online lum info for analysis use
- Offline "normalization" taken into account
- Access tools for analysis available
- Used by analysis

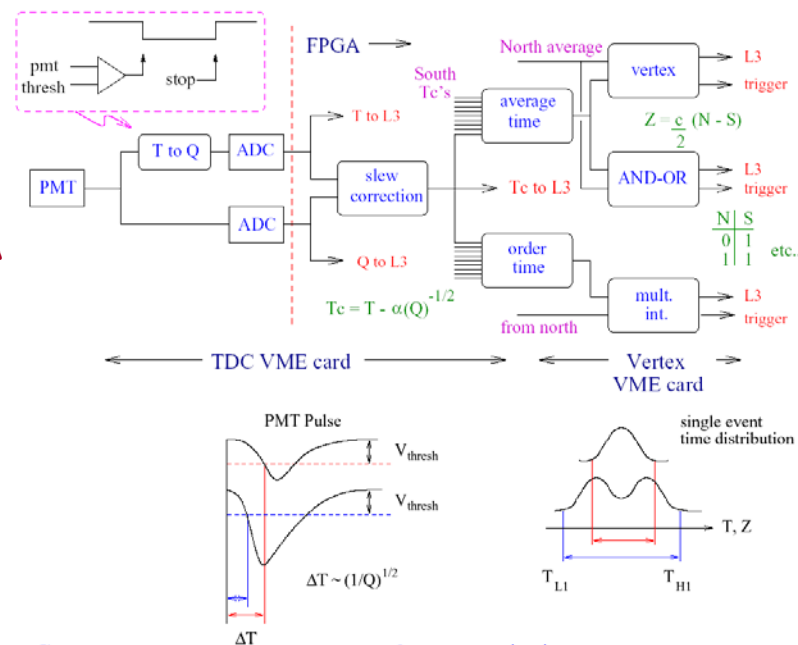
Future:

- ❖ Store info in database instead of flat files
- ❖ Implement this approach

- o Standard readout (DAQ, Level 3 to offline) of LM counters not available yet
- o Simulation & analysis of data not started

Hardware

- To enable readout of LM counters through standard DAQ, need 2 electronics cards: TDC & Vertex card.
- All TDC cards in hand; tested at Brown, now working on getting to work at DØ; mostly FPGA programming
- Vertex card: design complete, being laid out, expect at FNAL in 2 months; 0th order FPGA code exists
- Estimate when ready for readout: ~ end of 2003



DAQ & Analysis (downstream of above)

- Establish LM counter readout through DAQ (unpacker, other code)
- Establish analysis code for detector system

No effort on this

This will enable reading the counters → analyze data → use LED calib system, **calibrate & monitor** system, measure efficiency, etc

Simulation

- Establish Generator (processes) code to be used for simulation
- Establish simulation of LM system
- Determine **acceptance** (will require analysis code, mentioned before)

← No effort on this yet

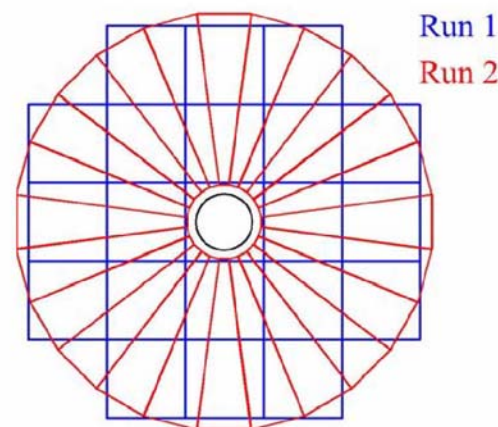
Use the Run I number for σ_{eff} .

The Run I numbers were:

Efficiency = 90.7 ± 1.7 %

Acceptance = 97.1 ± 2.0 % (use; > now)

Assign a 10% error to cover uncertainties.



Until these items are completed the 10% error assigned to the luminosity will not be reduced.



Results from lum system 1

H.Weerts

Acquired Luminosity

Year	Month	Store Time (hours)	Luminosity (pb ⁻¹)			Events (millions)
			Delivered	Recorded	Processed	
2000	October		0.04			
	November		0.04			
2001	April					
	June	208.5	0.05			
	July	125.6	0.76			
	August	356.1	4.35	0.08	0.08	1.7
	September	375.6	4.77	0.50	0.50	5.8
	October	61.8	1.15	0.06	0.06	0.9
	November	16.8	0.17	0.00	0.00	0.1
	December	336.4	4.30	0.23	0.23	3.9
2002	January	307.1	3.56	0.16	0.16	3.8
	February	267.5	5.47	1.68	1.65	13.4
	March	332.1	6.59	2.44	2.25	11.8
	April	249.2	7.71	3.05	2.45	12.1
	May	295.4	10.48	3.07	2.58	10.4
	June	89.6	1.32	0.52	0.37	3.0
	July	282.8	9.21	5.40	2.26	21.6
	August	316.4	11.09	6.35	2.87	22.5
	September	367.1	16.49	9.24	7.27	29.4
	October	378.3	21.65	13.92	13.87	34.2
	November	354.0	20.60	15.44	15.36	35.1
	December	370.4	22.65	17.08	16.74	37.2
2003	January	147.8	8.88	6.57	6.18	19.2

Moriond 2003 Sample

Year	Month	In Store (hours)	Luminosity (pb ⁻¹)				Events (millions)
			Delivered	Recorded	Processed	p13.04/5/6	
2002	June	89.6	1.32	0.52	0.37		3.0
2002	July	282.8	9.21	5.40	2.26		21.6
2002	August	316.4	11.09	6.35	2.87	1.30	22.5
2002	September	367.1	16.49	9.24	7.27	7.09	29.4
2002	October	378.3	21.65	13.92	13.87	13.36	34.2
2002	November	354.0	20.60	15.44	15.36	15.05	35.1
2002	December	370.4	22.65	17.51	17.08	17.08	37.2
2003	January	147.8	8.88	6.57	6.18	6.18	19.2
Moriond		2306.4	111.89	74.95	65.26	60.06	202.2

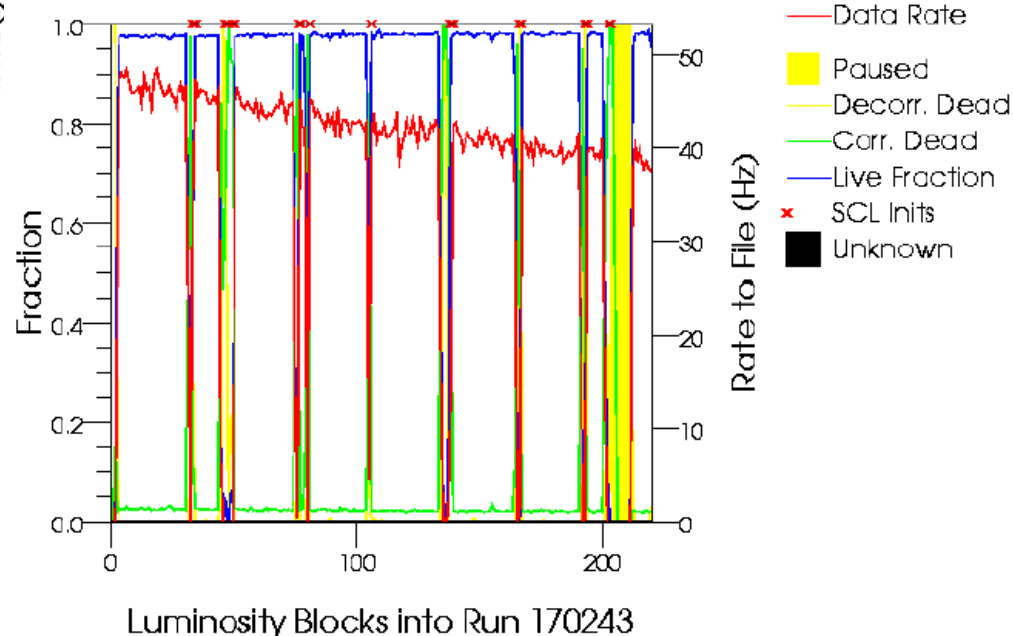
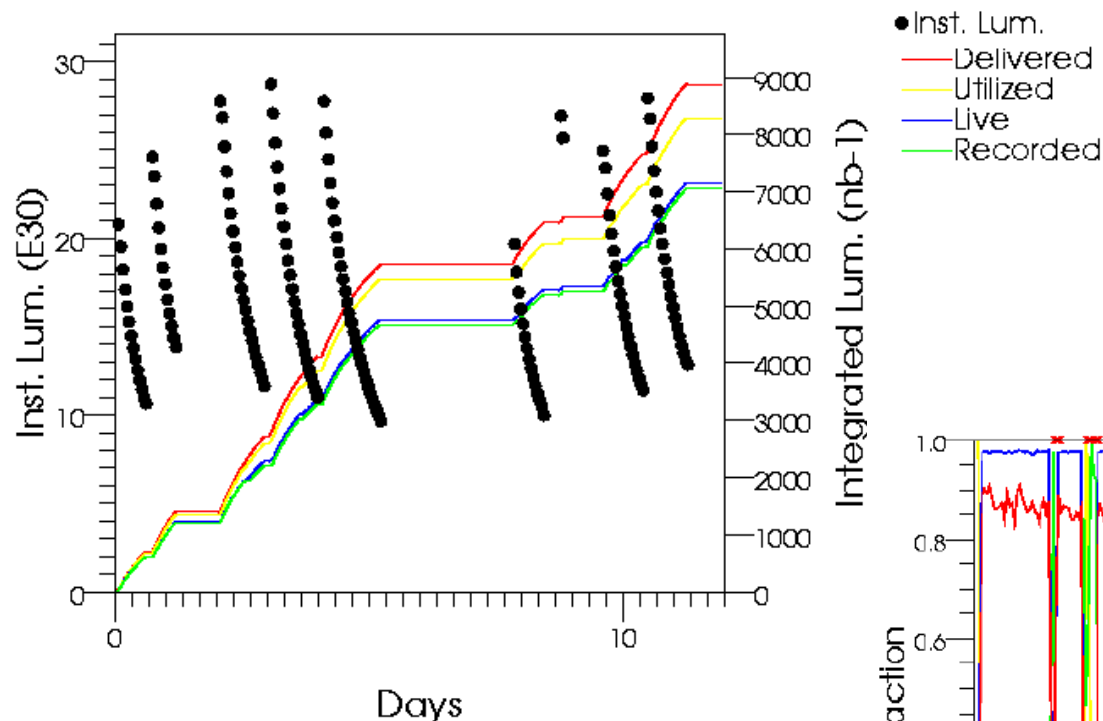
Evidence of a working system



Results from lum system 2

H.Weerts

Monthly/weekly performance reports



Lots of impressive information on the luminosity ID WEB page



Hardware

Observations:

Luminosity currently has a 10% error assigned to cover uncertainty in efficiency and acceptance of counters.
LM counter performance not monitored

Cross sections can not be determined with the current "measurement" of luminosity.

Recommendations:

1. Not being able to read the LM counters for monitoring and to determine the efficiency is unacceptable (timescale for completion with current effort is towards end of 2003)
2. Manpower has to be increased on electronics so that it can be completed (at least one electronics engineer and electronic tech part time).
3. Effort to include the LM counters (requires item 2)) in the DAQ system, and making it available for offline analysis should start now. New groups ?
4. Are there alternative ways to determine relative efficiency or even absolute efficiency ? Not pursued yet.

The complete lum effort is woefully understaffed



Analysis & accuracy

Observations:

Luminosity currently has a 10% error assigned to cover uncertainty in efficiency and acceptance of counters.

Cross sections can not be measured with the current "measurement" of luminosity.

Recommendations:

1. Effort to measure the real acceptance of detector has to be started immediately (Mainly simulation effort) Additional groups ?
2. In general DAQ & Analysis of LM counter data has to be implemented and established
3. This effort also needed to monitor/measure efficiency of hardware (readout & analysis of data).

Not considered the question: Which cross sections should be used in converting LM coincidences to luminosity. Leave to ID group and/or other body (EB ?).

The complete lum effort is woefully understaffed



Observations:

1. DØ determines a measure of the luminosity based on measured cross sections by other experiments, using the LM detector coincidences
2. DØ has an extremely reliable, well designed, battle proven online lum DAQ and book keeping system
3. This system delivers a luminosity for every data set taken
4. Monitor & first consistency checks of standard DAQ
5. Online system in current form will be good for the remainder of Run II (except for small upgrades); support by online group

Recommendations:

No major recommendations except documentation is needed

The complete lum effort is woefully understaffed



Offline

Observations:

1. Luminosity information is available for offline analysis in flat files
2. Tools exist to access the information for analysis ("good" lum or "not" and integrated lum)
3. System exists to feedback "offline" normalization (loss of data offline) to online files to "correct" lum
4. Need for luminosity info at remote institutions is becoming apparent
5. Analysis Tools group writing tools (access, streaming)

Recommendations:

1. The offline luminosity information should be stored in a database (scalability, satisfy all offline needs, streaming, etc.).
2. A design exists and it should be implemented as soon as possible. Currently database expertise from CD is here (actually has been there for long time and may go away). Take advantage of this **now**.
3. This database would contain more information than the current flat files and would serve all offline luminosity needs (from analysis to weekly and monthly reports, feed WEB pages, etc.)
4. To accomplish item 1) **physicist help** is **essential and needed now**. Estimate is additional **2.5FTE for 6 months** to make sure that database satisfies all needs of experiment and that access methods are what users in **whole** collaboration need.

The complete lum effort is woefully understaffed



General

Observations:

1. Current luminosity system works very well and provides a very precise luminosity number to the analyses (good book keeping, constantly updating)
2. The luminosity returned for analysis has inherent uncertainties which are covered by a 10% error, but which are undetermined

Recommendations:

1. An immediate influx of people is needed to get this system to the precision required for publishing cross sections from Run II. It requires a long time commitment by individuals and/or groups.
2. Documentation of the whole system needs to be produced

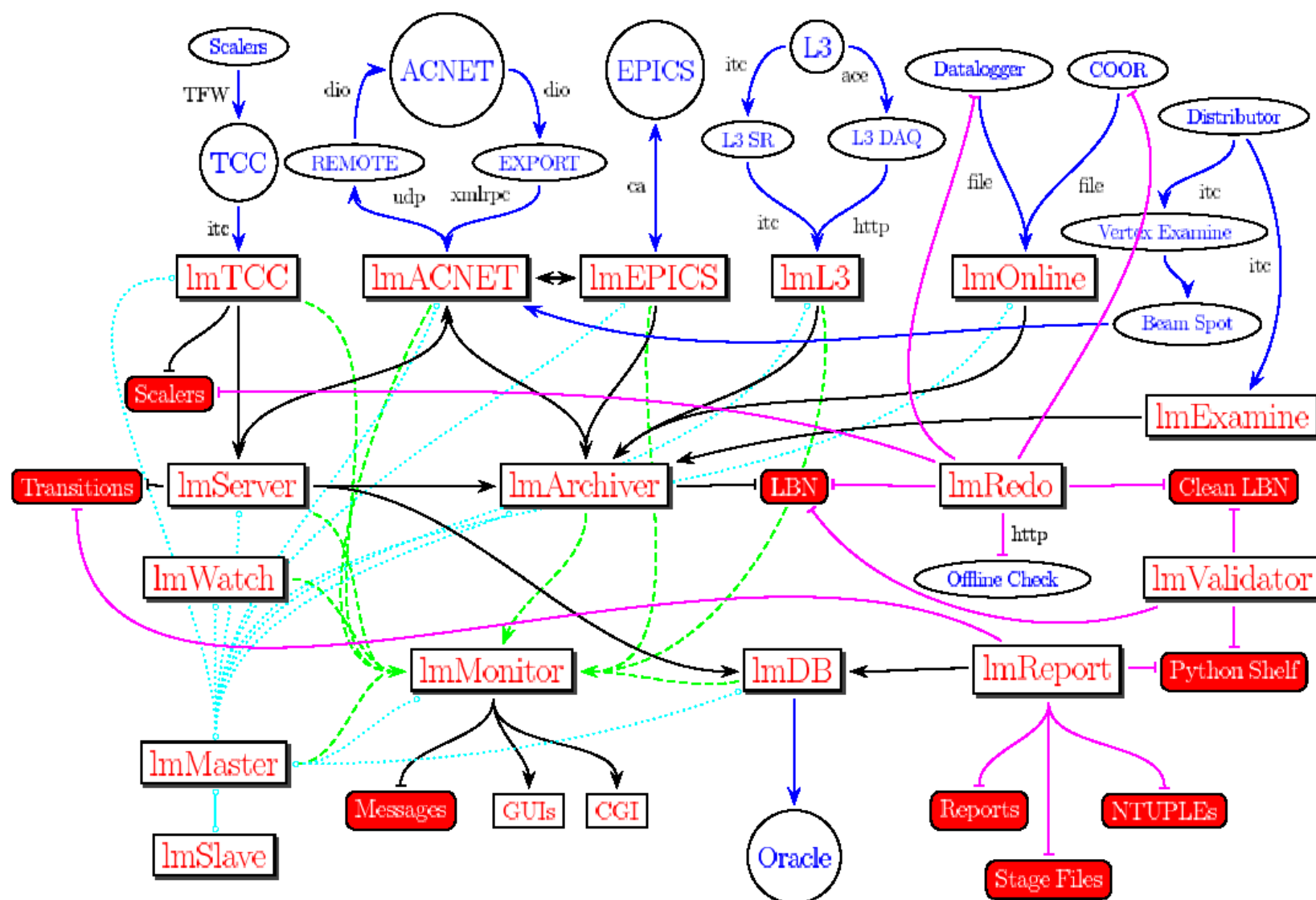
Conclusion:

Impressive & functional system has already been implemented thanks to the very hard & dedicated effort of few people.

The complete lum effort is woefully understaffed

Got
this ?

Luminosity Data Acquisition





Acquired Luminosity

Year	Month	Store Time (hours)	Luminosity (pb ⁻¹)			Events (millions)
			Delivered	Recorded	Processed	
2000	October		0.04			
	November		0.04			
2001	April					
	June	208.5	0.05			
	July	125.6	0.76			
	August	356.1	4.35	0.08	0.08	1.7
	September	375.6	4.77	0.50	0.50	5.8
	October	61.8	1.15	0.06	0.06	0.9
	November	16.8	0.17	0.00	0.00	0.1
	December	336.4	4.30	0.23	0.23	3.9
2002	January	307.1	3.56	0.16	0.16	3.8
	February	267.5	5.47	1.68	1.65	13.4
	March	332.1	6.59	2.44	2.25	11.8
	April	249.2	7.71	3.05	2.45	12.1
	May	295.4	10.48	3.07	2.58	10.4
	June	89.6	1.32	0.52	0.37	3.0
	July	282.8	9.21	5.40	2.26	21.6
	August	316.4	11.09	6.35	2.87	22.5
	September	367.1	16.49	9.24	7.27	29.4
	October	378.3	21.65	13.92	13.87	34.2
	November	354.0	20.60	15.44	15.36	35.1
	December	370.4	22.65	17.08	16.74	37.2
2003	January	147.8	8.88	6.57	6.18	19.2

Moriond 2003 Sample

Year	Month	In Store (hours)	Luminosity (pb ⁻¹)				Events (millions)
			Delivered	Recorded	Processed	p13.04/5/6	
2002	June	89.6	1.32	0.52	0.37		3.0
2002	July	282.8	9.21	5.40	2.26		21.6
2002	August	316.4	11.09	6.35	2.87	1.30	22.5
2002	September	367.1	16.49	9.24	7.27	7.09	29.4
2002	October	378.3	21.65	13.92	13.87	13.36	34.2
2002	November	354.0	20.60	15.44	15.36	15.05	35.1
2002	December	370.4	22.65	17.51	17.08	17.08	37.2
2003	January	147.8	8.88	6.57	6.18	6.18	19.2
Moriond		2306.4	111.89	74.95	65.26	60.06	202.2

Evidence of a working system